PLEASE READ THE FRONT OF THIS EXAM NOW.

Name____________________ Alpha ______________

Instructor__________________ Section # ___________

SP 211 FINAL EXAM

VERSION A

14 DECEMBER 1999

0755 - 1055

INSTRUCTIONS, ETC.

1. *Do not open the exam until told to do so.*

2. Please fill in the top of this sheet now.

3. While you are working on the exam, mark your answers on the exam by circling the letter corresponding to the best answer. After you have finished working on the exam or at 1055, whichever is first, you will fill out a separate answer sheet then turn in all paperwork associated with the exam.

4. *Your instructor may not assist you in interpreting any of the questions on the exam.*

5. There is *no* penalty for guessing.

6. The exam contains a few "double" problems where two problems deal with the same scenario. The answers do *not* depend upon one another i.e. There is no "double jeopardy."

7. During the exam you may use the official, yellow equations sheet, a calculator, a writing instrument and instructor-supplied scratch paper.

8. In order to leave enough space for calculations, add extra diagrams or figures and make an attempt at legibility and clarity of statement, it was necessary to increase the number of pages relative to previous final exams (Each problem now takes up more space.). When considering the "length," please keep in mind that this exam could easily have been fit into half the number of pages.

Note: Ignore air resistance (or air drag) for all questions except for question 14.
Note: All questions except 34, 35, 36 and 37 "take place" on the surface of the earth.

1. The position as a function of time, x(t), of a particle moving in one dimension is given by $x(t) = bt^5 + ct^4$. The position has units of meters (m), time has units of seconds (s) and b and c are constants. The units of b are

A. m.

B. m/s.

C. m/s^2.

D. m/s^4.

E. m/s^5.

2. The velocity of a particle at an early time is represented by $\mathbf{v}_1$ and at a later time by $\mathbf{v}_2$. The direction of the average acceleration over that time interval is

E. not shown because the average acceleration is zero.

3. The zigzag path which a bug travels is shown below. The magnitude of the displacement of the bug in traveling from point A to point B is

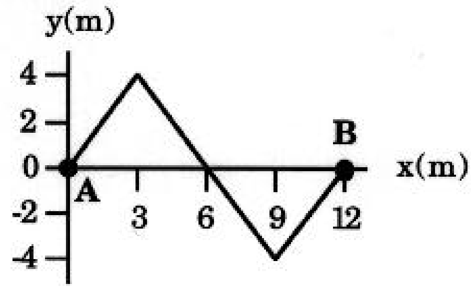
A. 0.

B. 12 m.

C. 14 m.

D. 16 m.

E. 20 m.



4. The position, x, vs. time, t, for an object moving in one dimension is shown below. The position, velocity and acceleration, respectively, at point P are

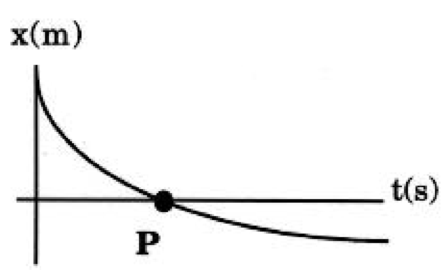
A. zero, positive and positive.

B. zero, positive, and negative.

C. positive, zero and positive.

D. positive, negative and zero.

E. zero, negative and positive.



5. A car accelerates from rest at 8.3 m/s^2 for 50 m, then brakes with an acceleration of -9.2 m/s^2 and comes to a stop. The total distance traveled is

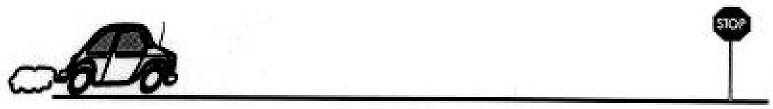
A. 85 m.

B. 90 m.

C. 95 m.

D. 100 m.

E. 105 m.



6. A particle is traveling counterclockwise around a circular path of radius 5 m. At the point shown it has a speed of 6 m/s and is speeding up at a rate of 4 m/s^2. The total acceleration of the particle is

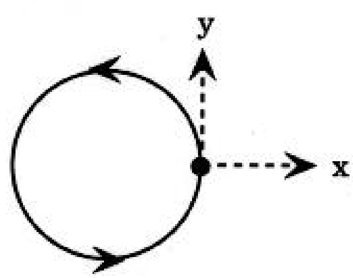
A. $(-7.2\mathbf{i} + 4\mathbf{j})$ m/s^2.

B. $(7.2\mathbf{i} - 4\mathbf{j})$ m/s^2.

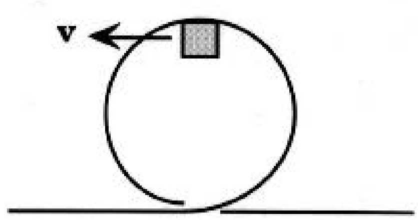
C. $(4\mathbf{i} + 7.2\mathbf{j})$ m/s^2.

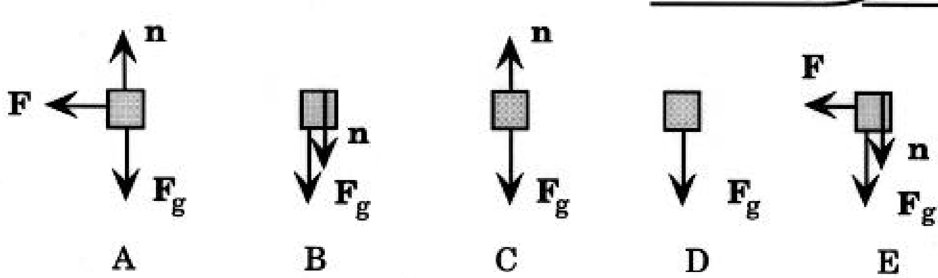
D. $(-7.2\mathbf{i} + 9.8\mathbf{j})$ m/s^2.

E. $(4\mathbf{i} - 9.8\mathbf{j})$ m/s^2.



7. A block is sliding around a frictionless loop-the-loop in the counterclockwise direction. The block is traveling fast enough such that it is always in contact with the loop-the-loop. The best free-body diagram for the object when it is at the top of the loop-the-loop is





8. A ball traveling horizontally with a speed of 2 m/s leaves a 1.2 m high table. With respect to the coordinate axes shown, the velocity of the ball just before it strikes the floor is

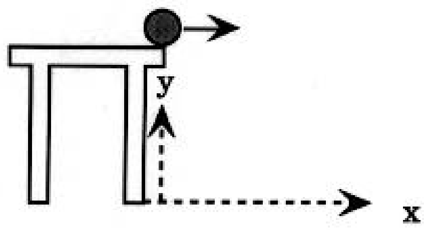
A. 6.8 m/s.

B. (2.4**i** - 9.8**j**) m/s.

C. (2.4**i** + 7.7**j**) m/s.

D. (2**i** - 7.7**j**) m/s.

E. (2**i** - 4.8**j**) m/s.



9. The system shown below is in equilibrium. The spring scale is calibrated in newtons. Neglect the masses of the pulleys and strings. The reading on the spring scale is

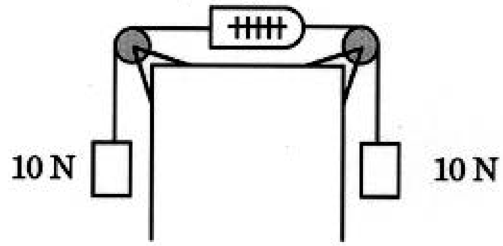
A. 10 N.

B. 20 N.

C. 5 N.

D. 40 N.

E. none of the above.



10. A cannon fires a projectile at an angle of 30° above the horizontal. The shell has an initial speed of 300 m/s. The maximum height reached by the shell, y_{max}, is

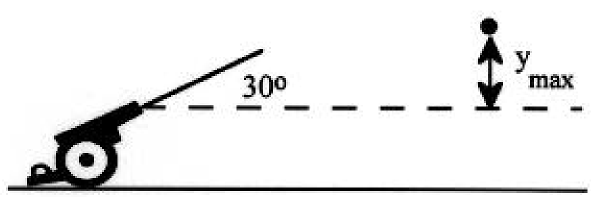
A. 899 m.

B. 946 m.

C. 1002 m.

D. 1148 m.

E. 1205 m.



11. A car is pushing a small, light box (1) which is pushing a large, heavy box (2) as shown below. The boxes move on a frictionless surface but there is friction between the tires of the car and the surface. The boxes and the car are moving and accelerating together to the right. $|\mathbf{F}_{i \text{ on } j}|$ represents the magnitude of the force of object i on object j and $|\mathbf{a}|$ is the magnitude of the acceleration. The following equation is *not* correct.

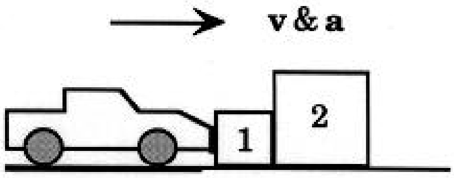
A. $|\mathbf{F}_{1 \text{ on } 2}| = |\mathbf{F}_{2 \text{ on } 1}|$

B. $|\mathbf{F}_{\text{car on } 1}| > |\mathbf{F}_{2 \text{ on } 1}|$

C. $|\mathbf{F}_{\text{car on } 1}| = m_1|\mathbf{a}|$

D. $|\mathbf{F}_{\text{car on } 1}| = |\mathbf{F}_{1 \text{ on car}}|$

E. $|\mathbf{F}_{1 \text{ on } 2}| = m_2|\mathbf{a}|$



12. A 2 kg block is hung using massless strings and the system is in equilibrium. The tension in the *horizontal* string is

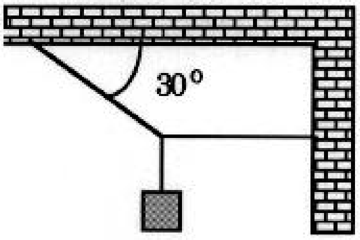
A. 19.6 N.

B. 25 N.

C. 29 N.

D. 34 N.

E. 40 N.



13. Three blocks connected by massless ropes slide together on a horizontal, frictionless surface. The tension in rope 1 (the rope between the two 4 kg blocks) is 12 N. The force, F, is

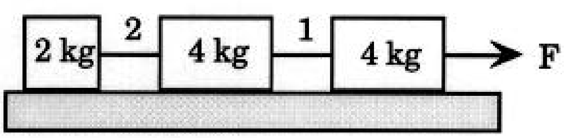
A. 15 N.

B. 20 N.

C. 30 N.

D. 35 N.

E. 40 N.



14. A bowling ball (m= 6 kg, A= 0.037 m^2), a basketball (m= 0.6 kg, A= 0.043 m^2) and a baseball (m= 0.145 kg, A= 0.0042 m^2) are dropped at the same time from a height of 100 m. (A is the cross-sectional area of the falling object measured in a plane perpendicular to its motion.) Taking air resistance into account, the order in which they hit the ground (first, second and third) is

A. bowling ball, basketball, baseball.

B. basketball, baseball, bowling ball.

C. bowling ball, baseball, basketball.

D. baseball, bowling ball, basketball.

E. baseball, basketball, bowling ball.

15. A truck moving on a flat horizontal road negotiates a curve, the radius of which is 50 m. The truck is traveling with a constant speed of 10 m/s. The minimum coefficient of static friction between the tires and the pavement so that the truck makes it around the curve is

A. not possible to calculate because the mass of the truck is not given.

B. 0.1.

C. 0.4.

D. 0.3.

E. 0.2.

16. A car is pushing an 8 kg block up a hill inclined at an angle of 30° above the horizontal. The force of the car on the block is 50 N parallel to the road. The work done by the car on the block when the block moves 30 m along the road is

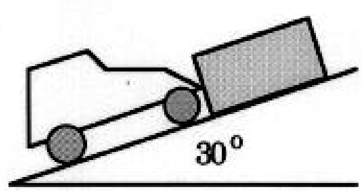
A. 1500 J.

B. 750 J.

C. 1200 J.

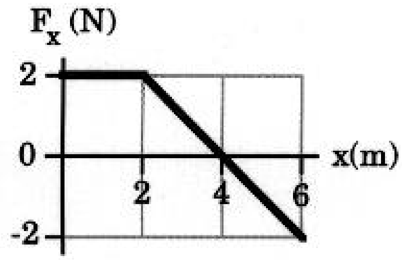
D. 2350 J.

E. 1300 J.



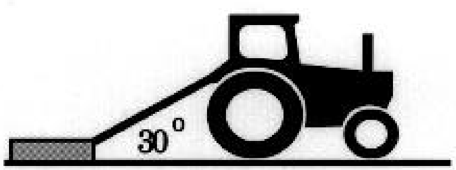
17. A particle is subjected to the net force given by the solid, dark line. As the particle travels from the origin to x=6 m, the change in kinetic energy is

A. 2 J.
B. 6 J.
C. 8 J.
D. 4 J.
E. 1 J.



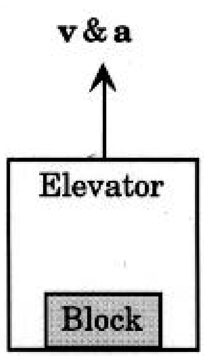
18. A box is dragged along a rough, horizontal surface by a rope at an angle of 30° above the horizontal as shown. The tension in the rope is 300 N. In order to move the box in a straight line horizontally for 5 m at a constant speed of 2 m/s, the *power* input to the box via the rope is

A. 520 W.
B. 600 W.
C. 340 W.
D. 790 W
E. 1300 W



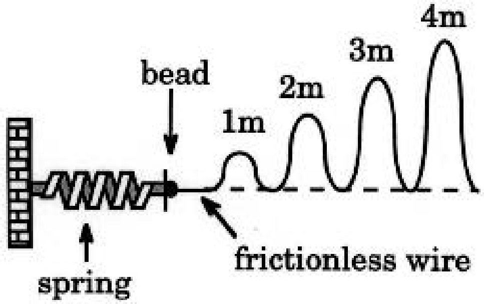
19. A block of wood is on the floor of an elevator. The velocity and acceleration of the elevator and block are both upward. The force of the *block on the elevator* is

A. the weight of the block.
B. tension.
C. a normal force.
D. a friction force.
E. a gravitational force.



The following two problems refer to the configuration shown. A spring with a force constant of 100 N/m is compressed 0.25 m. When released, the spring launches a 0.1 kg bead along a frictionless wire track which is shaped into an initial horizontal section followed by four hills of heights 1, 2, 3 and 4 m as shown.

20. Just after launch (before beginning to climb the first hill), the speed of the bead is



A. 4.4 m/s.

B. 6.3 m/s.

C. 7.9 m/s.

D. 8.8 m/s.

E. 9.5 m/s.

21. The number of hills (or height of the highest hill in meters) which the bead gets over is

A. 0.

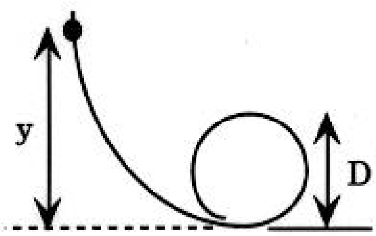
B. 1.

C. 2.

D. 3.

E. 4.

22. A bead starts at a height of y=7 m above the *bottom* of a frictionless, circular loop-the-loop of diameter D=2 m. The speed of the bead when it is at the *top* of the loop-the-loop is



A. 10.8 m/s.

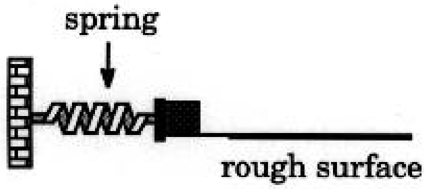
B. 8.8 m/s.

C. 7.9 m/s.

D. 9.9 m/s.

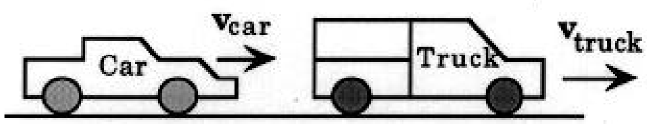
E. not possible to calculate because the mass of the bead is not given.

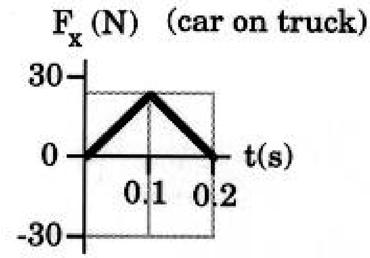
23. A spring with force constant 40 N/m is compressed 0.3 m. When released, the spring launches a 0.2 kg block along a horizontal track, the first part of which is frictionless. When the block encounters a rough surface, it slows down and comes to rest after traveling 4.6 m. The coefficient of friction between the rough surface and the block is



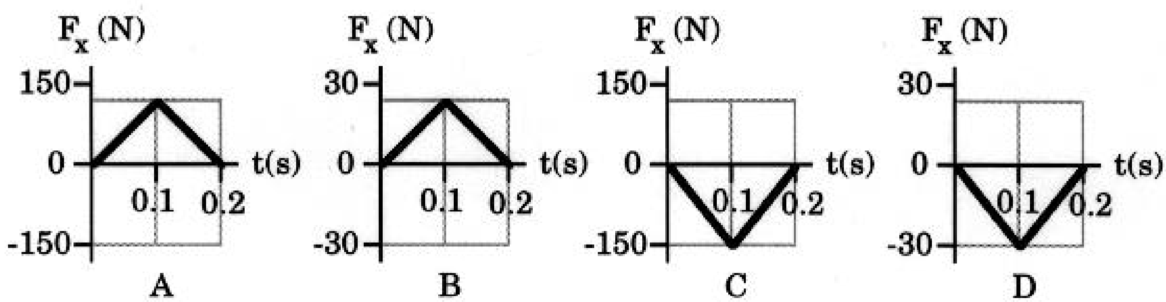
A. 0.2.
B. 0.3.
C. 0.4.
D. 0.5.
E. 0.6.

The following two problems refer to a toy car (0.1 kg) which runs into the back of a moving toy truck (0.5 kg). A plot of the force of the *car on the truck* vs. time (solid, dark line) during the collision is shown.





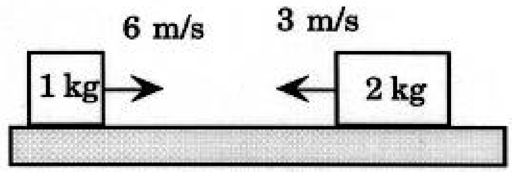
24. The plot which best represents the force of the *truck on the car* vs. time during the collision (Yes, there are only four possible answers.) is



25. If the truck is initially traveling +3 m/s (3 m/s to the right), the velocity of the truck after the collision) is

A. + 6 m/s.
B. + 9 m/s.
C. + 3 m/s.
D. + 5 m/s.
E. + 4 m/s.

The following two problems refer to two boxes on a horizontal, frictionless surface. The boxes are sliding toward one another as shown and subsequently collide.



26. If the boxes stick together (the collision is perfectly inelastic), the velocity of the 1 kg box after the collision is

A. 3 m/s to the right.

B. 3 m/s to the left.

C. 1 m/s to the right.

D. 1 m/s to the left.

E. 0.

27. If the collision is elastic, the velocity of the 1 kg box after the collision is

A. 3 m/s to the left.

B. 3 m/s to the right.

C. 6 m/s to the left.

D. 6 m/s to the right.

E. 0.

28. A collection of four particles is shown below. They are located at the corners of a rectangle with sides of 2m and 4 m. The center of mass of the system is located at:

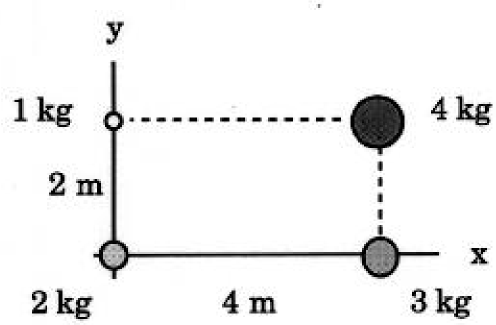
A. (2, 1) m.

B. (2.4, 0.6) m.

C. (4, 2) m.

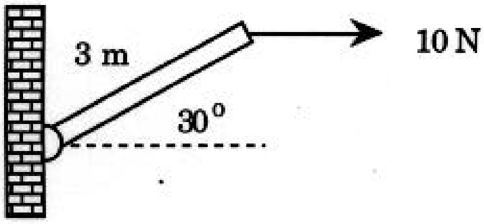
D. (3, 1.2) m.

E. (2.8, 1) m.



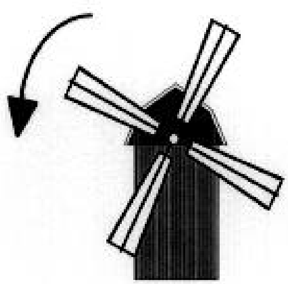
29. A horizontal force of 10 N acts at one end of a 3 m long board which is connected to a wall by a hinge at the other end. When the board is at an angle of 30° above the horizontal, the torque on the board about the hinge due to the 10 N force is

A. 26 N-m out of the page.
B. 15 N-m into the page.
C. 10 N-m into the page.
D. 21 N-m into the page.
E. 30 N-m out of the page.



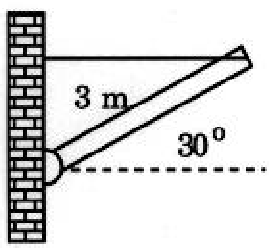
30. A windmill is turning 100 rpm (rev/min) when the wind suddenly quits. After the wind quits, the windmill slows down with an acceleration of 25 rev/min^2. The number of revolutions that the windmill turns between the time that the wind stops and the time that the windmill stops turning is:

A. 400 rev.
B. 500 rev.
C. 300 rev.
D. 200 rev.
E. 100 rev.



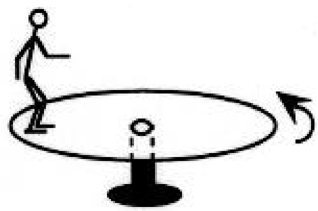
31. A 3 m long uniform board of mass 20 kg is connected to a wall by a horizontal, massless rope at one end and by a hinge at the other end. The board is at an angle of 30° above the horizontal If the system is in equilibrium, the tension in the rope is

A. 98 N.
B. 196 N.
C. 170 N.
D. 294 N.
E. 226 N.



32. A 70 kg person is riding a merry-go-round which is initially rotating about its center at 0.5 rev/s. The person is initially 2 m from the center. The moment of inertia of the merry-go-round without the person is 2240 kg-m^2. The person walks toward the center to a final position of 1 m from the center. If the person is assumed to be (modeled by) a point mass, the final angular speed of the merry-go-round and person is:

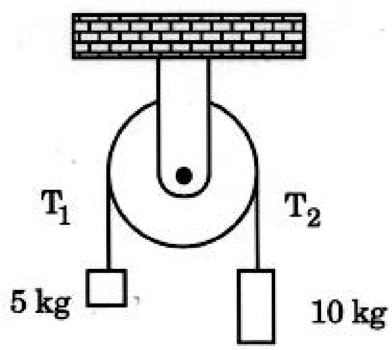
A. 0.40 rev/s.
B. 0.45 rev/s.
C. 0.50 rev/s.
D. 0.55 rev/s.
E. 0.60 rev/s.



Side View

33. A rope has a 5 kg mass at one end and a 10 kg mass at the other. The rope passes over a 20 kg cylinder which can rotate about a fixed axis without friction. The rope does not slip on the cylinder i.e. the rope can turn the cylinder without slipping. T_1 and T_2 are the tensions in the rope on the left and right sides of the cylinder, respectively. The following is true.

A. $98\text{ N} > T_2 > T_1 > 49\text{ N}$.
B. $98\text{ N} = T_2 > T_1 = 49\text{ N}$.
C. $98\text{ N} = T_2 = T_1 = 49\text{ N}$.
D. $98\text{ N} > T_2 = T_1 > 49\text{ N}$.
E. The relationship between the forces can't be determined from the information given.



34. A planet has the *same mass* as the earth. It also has a *radius half* the earth's radius. If the earth's acceleration due to gravity is g, the acceleration due to gravity on the planet's surface is:

A. 1/4 g.
B. 1/2 g.
C. g.
D. 2g.
E. 4g.

The following two problems refer to a satellite of mass m circling a planet of mass M and radius R. The satellite is initially in an orbit 3R *from the center* of the planet and then changes to an orbit 4R *from the center* of the planet.

35. The minimum total mechanical energy required for the satellite to change orbit is

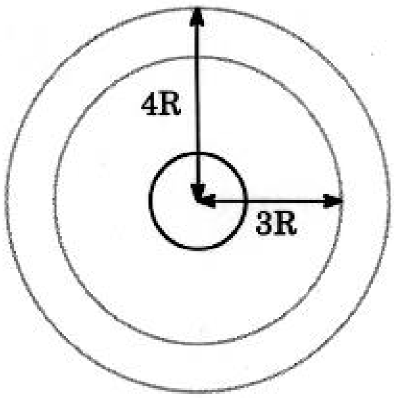
A. $\frac{GmM}{24R}$.

B. $\frac{GmM}{15R}$.

C. $\frac{GmM}{12R}$.

D. $\frac{2GmM}{21R}$.

E. $\frac{3GmM}{5R}$.



36. If the satellite has a mass m= 200 kg and the planet has a mass $M=3x10^{24}$ kg and radius $R=5x10^6$ m, the change in gravitational potential energy when the satellite changes orbit is

A. $9.8x10^9$ J.

B. $5.1x10^9$ J.

C. $3.3x10^8$ J.

D. $1.2x10^9$ J.

E. $6.7x10^8$ J.

37. A satellite orbits a planet at a distance of 10^7 m *from the center* of the planet (10^7 m is the radius of the orbit.). The satellite has an orbital period of 3 earth days. The mass of the planet is

A. $5.2x10^{22}$ kg.

B. $8.8x10^{21}$ kg.

C. $6.4x10^{23}$ kg.

D. $2.1x10^{25}$ kg.

E. $6.0x10^{24}$ kg.

38. The motion of a mass on a spring is described by the graph below. If the equation $x = A\cos(\omega t + \phi)$ is used to describe the motion, the amplitude, frequency and phase constant are

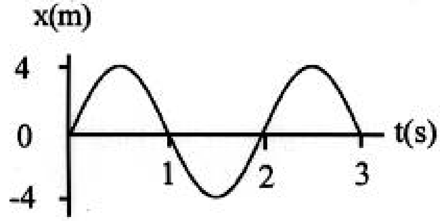
A. 4 m, 2 Hz and $+\pi/2$.

B. 8 m, 0.5 Hz and 0.

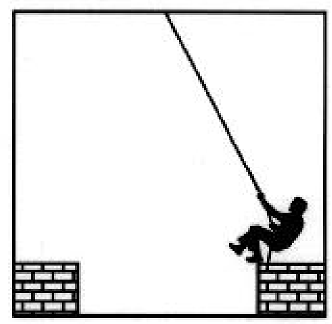
C. 8 m, 2 Hz and $-\pi/2$.

D. 8 m, 0.5 Hz and $+\pi/2$.

E. 4 m, 0.5 Hz and $-\pi/2$.



39. A person swings at the end of a 30 m long massless rope which is attached to the ceiling. Ignore friction and model the person as a point mass. If the person starts from rest, the time that it takes to get to the other side of the room (where the velocity is also zero) is:



A. 5.5 s.

B. 5 s.

C. 4.5 s.

D. 4 s.

E. 3.5 s

40. A 5 kg mass is connected to a massless spring. It is oscillating with an amplitude of 0.3 m. When the mass is halfway between the equilibrium position and the maximum displacement, the speed is 0.2 m/s. The spring constant is:

A. 5 N/m.

B. 11 N/m.

C. 3 N/m.

D. 16 N/m.

E. 7 N/m.

41. The power transmitted by a sinusoidal wave is proportional to

A. A.

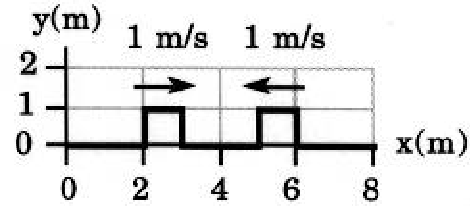
B. A^2.

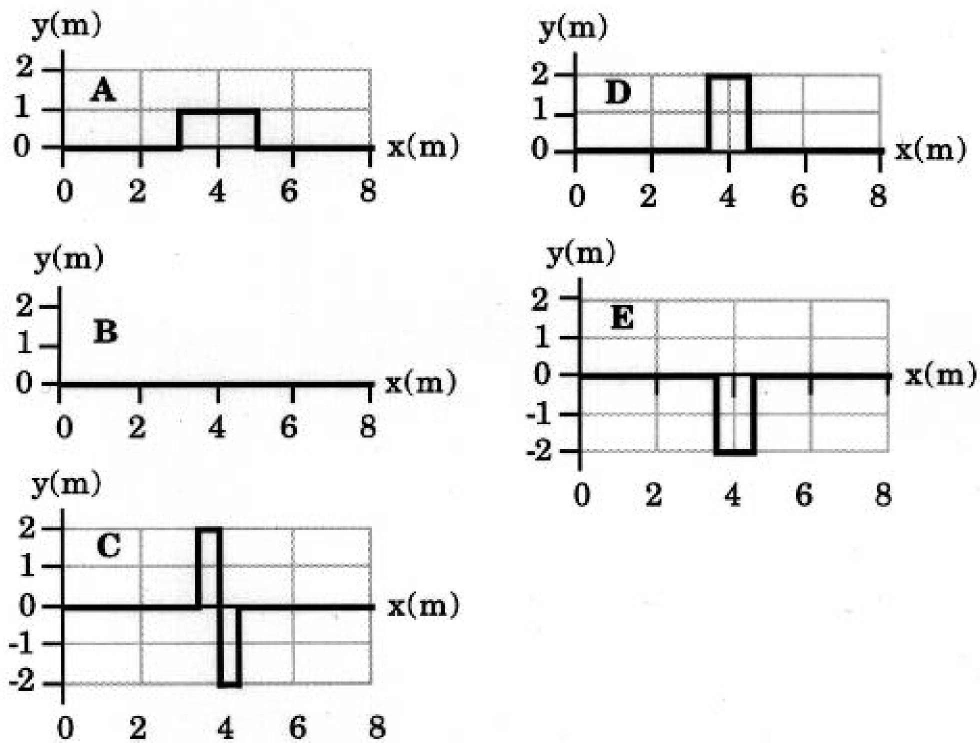
C. ω.

D. v^2.

E. t.

42. At t=0, square waves on a string are traveling toward one another and each has a speed of 1 m/s as shown at the right. At t=1.5 s, the shape of the string is





43. A string has a mass per unit length of 0.02 kg/m. A wave is traveling on the string and the wave is described by: $y = 0.1\text{ m} \sin(3x-6t)$
where x has units of meters, t has units of seconds and the "angle" is in radians. The tension in the string is

A. 0.02 N.

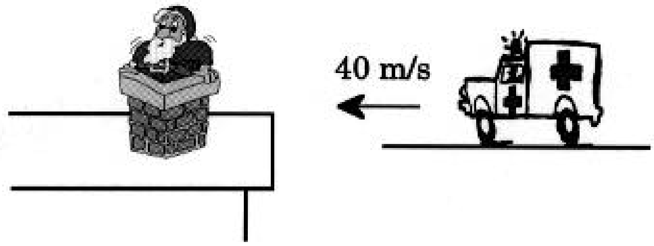
B. 0.06 N.

C. 0.12 N.

D. 0.18 N.

E. 0.08 N.

44. Santa is stuck in a chimney. A rescue vehicle is traveling toward him with a speed of 40 m/s. If the siren on the vehicle has a frequency of 2200 Hz and the speed of sound is 340 m/s, the frequency that Santa hears is



A. 2459 Hz.

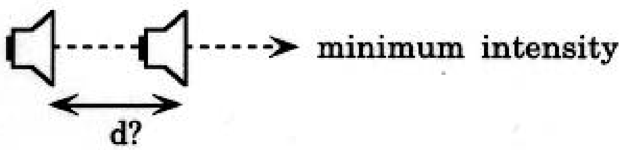
B. 2833 Hz.

C. 1968 Hz.

D. 2493 Hz.

E. 1941 Hz.

45. Two speakers are driven at 340 Hz by the same oscillator. The speakers are located along the x-axis. You may model the speakers as point sources of sound. If the speed of sound is 340 m/s, the separation between the speakers so that the sound along the x-axis is a *minimum* is



A. 1 m.

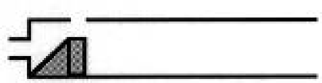
B. 0.75 m.

C. 0.5 m.

D. 0.25 m.

E. 0.125 m.

46. If the speed of sound is 340 m/s, the fundamental frequency of an organ pipe 2.5 m long and open at both ends is



A. 68 Hz.

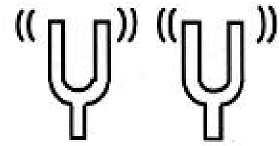
B. 51 Hz.

C. 34 Hz.

D. 136 Hz.

E. 102 Hz.

47. Tuning forks are vibrating with frequencies of 261 and 264 Hz. The sound that Albert hears



A. has a high intensity that is constant in time.

B. has an intensity (or loudness) that varies at 3 Hz.

C. has an intensity (or loudness) that varies at 1 Hz.

D. has an intensity (or loudness) that varies at 4 Hz.

E. has a low intensity that is constant in time.

48. A force sensor on the bottom of a submarine reads 1800 N when the submarine is submerged in seawater. The force sensor reads zero when the submarine is in dry dock. If the force sensor has an area of $2x10^{-3}$ m and the density of seawater is constant at about 1025 kg/m^3, the depth of the submarine is

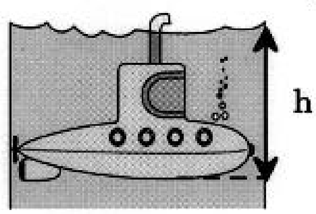
A. 85 m.

B. 75 m.

C. 80 m.

D. 95 m.

E. 90 m.



49. A cube of material is hung from a string which is attached to a scale. The cube is completely immersed in water which has a density of 1000 kg/m^3. The cube is 0.06 m on a side and has a mass of 0.4 kg. The reading on the scale is

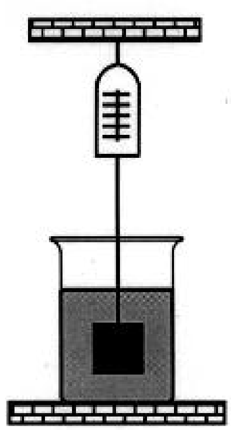
A. 2.8 N.

B. 3.9 N.

C. 1.8 N.

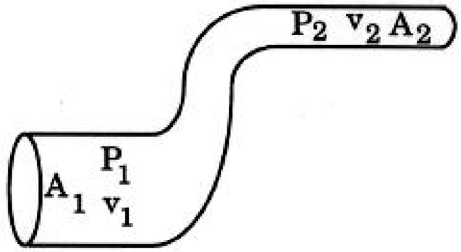
D. 2.3 N.

E. 3.2 N



50. A nonviscous, incompressible fluid undergoes steady, irrotational flow in a pipe. A section of the pipe is shown at the right. At a low elevation where the pressure is P_1 and the speed is v_1, the pipe has a large cross sectional area, A_1. At a high elevation, where the pressure is P_2 and the speed is v_2, the pipe has a small cross sectional area, A_2. The following is true.

A. $v_2>v_1$ and $P_2<P_1$.
B. $v_2>v_1$ and $P_2>P_1$.
C. $v_2<v_1$ and $P_2>P_1$.
D. $v_2<v_1$ and $P_2<P_1$.
E. $v_2=v_1$ and $P_2=P_1$.



51. The version of the exam which you have is

A. Version A.
B. Version B.

52. The letter at the top of this page is

A. A.
B. B.

Note: When you have finished working on the exam, obtain a SCANTRON answer sheet from your instructor and proceed as follows.

1. Please fill in the top of the answer sheet with your alpha code and section number. (There is an example on the back of this exam.)

2. Please print your name and your instructor's name in the spaces on the right of the answer sheet. (There is an example on the back of this exam.)

3. *Carefully* transfer your answers from the exam to the "bubbles" on the answer sheet. If you make a mistake and cannot erase cleanly, get a new answer sheet from your instructor and start over.

4. Turn in the answer sheet, exam and scratch paper to your instructor.